



National scale assessment of landslide hazard and risk in Italy

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Establishing landslide hazard and risk for an entire nation is a difficult task and only a few, largely empirical, attempts have been pursued. The main difficulty to determine landslide hazard, and to ascertain the associated risk, for very large areas lies in the complexity and diversity of the landslide phenomena, and in the limited availability of relevant information for territories extending for hundreds of thousands of square kilometres. In Italy, relevant information has become available to attempt a quantitative, nationwide (synoptic) assessment of landslide hazard and of the associated risk to the population. To determine landslide hazard in Italy we adopted a simplified version of a recently proposed probabilistic model to determine landslide hazard at the basin scale. The simplified model ascertains landslide hazard as the joint probability: (i) of the spatial (geographical) probability of landslide events (i.e., “where” landslides are expected), and (ii) of the temporal probability of landslide occurrence (i.e., “when” or “how frequently” landslides are expected). We prepared two separate hazard models. The first model forecasts the occurrence of all damaging landslide events (general landslide hazard model), and the second model predicts landslide events that may result in casualties (landslide risk to the population model). The municipality - an administrative/political subdivision - was selected as the mapping unit of reference. To prepare the two hazard/risk models we exploited two detailed catalogues listing information on damaging landslides, and on landslides with human consequences in Italy. The two catalogues cover the 52-year period from 1950 to 2001. For modelling purposes, the catalogues were split in two sub-sets: (i) a model training set covering the 41-year period from 1950 to 1990, and (ii) a model validation set covering the 11-year period between 1991 and 2001. To estimate the temporal probability of landslide

occurrence (i.e., “when” or “how frequently” landslide events are expected), we first obtained an estimate of the average recurrence of landslide events in each municipality. Landslide event recurrence was obtained dividing the total number of damaging landslide events (or the total number of events with casualties) in each municipality by the time span of the investigated period (41 years). Next, the recurrence time of damaging landslide events (of landslide events with casualties) was assumed constant, and a Poisson probability model was selected to describe the temporal distribution of damaging landslide events (and of landslide events with casualties). Finally, the exceedance probability of having one or more damaging landslide event (or landslide event with casualties) in each municipality was computed for different periods, from 1 to 20 years. The spatial probability of landslides (i.e., “where” landslides are expected) was obtained through multivariate analysis of synoptic thematic information, including lithological, soil and climate data, and a set of morphometric variables obtained from a 90 m \times 90 m digital elevation model (DEM) acquired by the Shuttle Radar Topography Mission (SRTM) in February of 2000. As the dependent variable, the presence or absence of damaging landslides (or of landslides that have resulted in casualties) in each municipality was used. The temporal prediction models and the spatial prediction models were tested using independent landslide information, i.e., information not available to construct the models. Landslide validation sets covering the 11-year period between 1991 and 2001 were used to test the temporal models, the spatial models, and the joint hazard/risk models. Results of the hazard/risk modelling are shown here using synoptic maps that portray landslide hazard/risk in the 8103 Italian municipalities in five probability classes, from very low to very high. The maps, albeit preliminary, are remarkable, and may be used by national and regional civil protection authorities, by national and regional environmental agencies, and by insurance and re-insurance companies to determine levels of landslide hazards and of landslide risk to the population of Italy.